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RESEARCH ARTICLE

Vaccine Education, Reasons for Refusal, and Vaccination Behavior

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Introduction: Little is known about associations between the reasons parents refuse or delay vaccines for their children, their responsiveness to vaccine counseling, and their children's vaccination status at various ages. Since 2015, Michigan has required parents to attend education sessions at local health departments to receive nonmedical exemptions. This requirement provides an opportunity to study otherwise opaque aspects of vaccine refusal.

Methods: In 2017 and 2018, researchers analyzed a combined data set that included electronic medical records (n=4,098) generated by one Michigan health department during 2015 immunization education sessions, and immunization records from an August 2016 report of the Michigan Care Improvement Registry immunization registry. Analyses employed difference of proportions and ANOVAs to explore group differences in vaccination behaviors after education sessions and on-time vaccination status at various ages.

Results: Children whose parents stated a commitment to an alternative schedule at the education session subsequently received a vaccine their parents had refused at a much higher rate (39.2%) than did children whose parents refused for reasons of religion (4.4%), concerns about the risks of vaccines (8.1%), or beliefs that vaccines provide little benefit (10.5%).

Conclusions: Different reasons for refusal are associated with different patterns of vaccination behavior. Furthermore, results suggest that education sessions may overcome vaccine refusal in some cases, and that distinct refusal reasons mark real differences in parental motivations regarding vaccination choices. These differences in parental motivations may indicate the existence of different sites for potential pro-vaccination interventions.

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INTRODUCTION

Each U.S. state requires children to receive vaccines or document immunity to enroll in public school.[1,2] A total of 47 states offer religious exemptions, and 17 allow personal belief exemptions.[1,2] National rates of nonmedical exemptions (NMEs) remain low, but clustering of exemptions is associated with disease outbreaks.[3] In 2014, Michigan had one of the country's highest NME rates.[4] In December 2014, Michigan made it more difficult to receive NMEs, but continued to offer NMEs for religious and personal belief objections.[5] The new rule required those seeking NMEs to attend a local health department's immunization education session.[6] Research shows that communities with more burdensome NME application processes have lower NME rates.[7–9] Unsurprisingly, the number of NMEs for Michigan's kindergartners declined, from 4.8% in 2014 to 3.1% in 2015.[10]

Vaccine-hesitant parents differ according to the intensity of hesitancy and their reasons for being vaccine

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hesitant.[11–13] Some allow their children to receive all recommended vaccines, whereas others refuse or delay some or all vaccines.[14,15] The most popular reasons for vaccine refusal[16] include worries about vaccine safety,[17] a belief that vaccine-preventable diseases are mild or "natural" (and, therefore, that vaccines provide little benefit),[18] and religious objections.[19]

The first aim of this study is to identify associations between parents' reasons for refusing vaccines and rates at which their children subsequently received previously refused vaccines. This provides some sense of how mandatory vaccine education may influence future vaccination decisions for parents with different refusal reasons. The second aim is to examine associations between refusal reasons reported at education sessions and on-time vaccination rates for vaccines recommended by the Advisory Committee on Immunization Practices (ACIP).[20] This gives a fuller sense of the differences in vaccination behaviors between children whose parents refuse vaccines for different reasons.

METHODS

A 2014 amendment to the Michigan Administrative Code states that local health departments must provide parents with education about "the risks of not receiving the vaccines being waived and the benefits of vaccination to the individual and the community."[6] Oakland County Health Division (OCHD) implemented this requirement by providing one-on-one education from public health staff, during sessions lasting ≅30 minutes. During education sessions, OCHD waiver education staff recorded the date of each education session and identified the primary reason parents provided for each vaccine they refused.

Study Population

Data for this study come from deidentified electronic medical records generated by OCHD during 2015 immunization education sessions, matched using a unique code to deidentified immunization records from the Michigan Care Improvement Registry (MCIR) immunization database, generated in August 2016. Of the 4,167 records in the OCHD database of education sessions, 69 could not be matched to the MCIR database, yielding a sample of 4,098 children. A small number of cases (n=99) had missing data for refusal reason, either because parents changed their mind at the education session or because they requested a waiver for reasons other than refusal. These cases were excluded from analyses. Use of deidentified data was approved by human subjects IRBs at Oakland University and the Michigan Department of Health and Human Services.

Measures

Nine recorded refusal reasons were collapsed into four broader thematic categories that match the taxonomy of the vaccine refusal literature (Appendix Table 1, available online).[11,15,21] The reasons "believe natural immunity is better," "disease is gone from U.S.," and "disease is not serious" were coded as low benefit (n=342). "Autism," "vaccine ingredients/how produced," and "vaccine safety/side effects" were coded as high risk (n=2,055). "Too many doses/following alternative schedule" was coded as alternative schedule (n=1,181). "Religious" was coded as religion (n=542). The reason "shots can be painful" was eliminated from the analysis because the subgroup (n=4) was too small to be analytically useful and it did not fit thematically into one of the four other categories. In almost all cases, parents gave the same reason for each vaccine they refused (3,884/3,995=97.2%). This is in keeping with health lifestyle theory, which suggests health behaviors tend to emerge consistently from underlying health habitus rather than as a series of deliberative, rational choices.[22] In most analyses, cases where parents refused different vaccines for different reasons were excluded to focus on the behavior of the overwhelming majority of vaccine refusers, who can be characterized by their singular refusal reasons.

The data set also included the age of each child in months at the time the MCIR report was generated (August 2016), the date of each child's education session, and the dates for each of their immunizations. Immunizations were recorded by CVX number, which the authors mapped to the relevant ACIP-recommended vaccine series.[20,23] Education sessions occurred throughout 2015, and the MCIR report was generated in August 2016, so the MCIR data identifies vaccination status at between 7 and 19 months after education sessions. Rates of vaccine completion based on Michigan school requirements were calculated at age 6 years, the age limit for enrollment in kindergarten, and at age 13 years, the age past which few students enter seventh grade. Analysis of this longitudinal data focuses on the cohort of children who were aged >6 years by August 2016 (n=2,627) because this cohort was large enough to be analytically robust, and because most ACIP-recommended and school-required vaccines are to be completed by that age. Pneumococcal is included as it is recommended by ACIP and required by Michigan for childcare or preschool, though it is not required for kindergarten. However, data for *Haemophilus influenzae* type-b conjugate (Hib) vaccine compliance is not included, because ACIP recommends different Hib vaccination schedules for children who receive different brands of this vaccine. In some cases, the analysis includes a time point at age 6 years that is not part of the ACIP recommended schedule, in order to capture differences among the groups across a longer period of time. This is important for understanding the trajectory of the alternative schedule group. Further analysis focused on a smaller cohort of children who were aged >13 years by August 2016 (a subset of the cohort that was aged >6 years by August 2016; n=981), because this allowed identification of vaccination patterns with respect to vaccines Michigan requires for seventh grade, including meningococcal conjugate, varicella, and tetanus, diphtheria, acellular pertussis. Trend analyses for the cohorts aged 6 years and 13 years are not anchored by education dates.

Statistical Analysis

Analyses were conducted in 2017 and 2018. Difference of proportions tests were used to examine vaccination behavior before and after the education session, specifically whether rates of subsequently receiving a refused vaccine differ significantly by each refuser type compared with all others. In addition to the effect of the education session per se, differences in rates of completion by reason type for each vaccine at age 6 and age 13 years are assessed using ANOVA with pairwise comparison tests to locate specific

group differences (using Tamhane's T2 test as variances were unequal in all analyses). Similarly, ANOVA and corresponding post facto tests were performed for each vaccine at each recommended ACIP time point, and the rate of completion by refuser type was charted across these time points. All analyses were performed using a bootstrapped sampling distribution of 1,000 samples to account for potential distributional differences in the actual populations.

RESULTS

Analyses identified differences by refuser type on whether, in the 7- to 19-month period after the education session, the child received a vaccine their parents refused at the education session. Refusers in the religion refusal category were the least likely to subsequently receive a refused vaccine (4.4%, 24/542), followed by those in high risk (8.1%, 166/2,055), whereas those in low benefit were only slightly more likely to subsequently receive a refused vaccine (10.5%, 36/342). However, those in the alternative schedule category were substantially more likely to receive a previously refused vaccine (39.2%, 463/1,181). ORs comparing each group against the remainder of the sample demonstrate that children whose parents were in the alternative schedule category had nearly 9-fold higher odds of subsequently receiving a vaccine they had refused: alternative schedule (OR=8.722, 95% CI=7.306, 10.558, $p<0.001$); low benefit (OR=0.575, 95% CI=0.389, 0.781, $p=0.002$); high risk (OR=0.260, 95% CI=0.211, 0.315, $p<0.001$); and religion (OR=0.207, 95% CI=0.131, 0.294, $p<0.001$; Appendix Table 2, available online). The median length of time between education session and the endpoint for the data catchment period varies by <2 weeks between refuser group types, indicating that differences in the length of follow-up time between refuser groups are unlikely confounders for differences in subsequent vaccination rates.

Figure 1 shows how rates for meeting Michigan's school immunization requirements[24] vary by vaccine and refuser type. Table 1 corresponds to Figure 1 to show refuser-type group differences were significant for each disease at ages 6 and 13 years, with the exception of varicella at age 13 years.

The post facto tests presented in Table 1 highlight that the largest and most consistent between-group differences occur between alternative schedule and religion or high risk groups. By contrast, there is a less stable relationship between the completion rates for children of parents in the low benefit group and those of other groups. For example, children of parents in the low-benefit group have the highest vaccination rates for hepatitis B and polio at age 6 years (though by age 13 years, rates of those in the alternative schedule group mirror or surpass rates of the other groups). But for varicella at age 6 years, and meningococcal at age 13 years, children of parents in the low-benefit group have vaccination rates that are low enough to approach those of children whose parents are in the religion and high-risk groups.

Figure 2 illustrates completion rates by refuser type for six different vaccines, at each stage of the ACIP-recommended schedule in effect in 2015[25] for the cohort of children who were aged ≥6 years at August 2016 (n=2,627). Table 2 corresponds with Figure 2 to show the aggregate between-group differences and significant pairwise comparisons at each time point for each disease.

ANOVAs performed for each time point across each vaccine again show significant aggregate between-group differences at every time point for each vaccine (summarized in Table 2). As in the other tables, the largest and most consistent differences can be observed between children whose parents are in the alternative schedule group and those whose parents are in the religion group. These analyses also show, however, that these differences tend to grow over time. For measles, mumps, and rubella and polio, for example, there are no significant differences between children whose parents are in the alternative schedule and religion groups at the earliest time points for recommended vaccines. However, by age 6 years children of parents in the alternative schedule group have reached significantly higher completion rates than those from the religion group.

DISCUSSION

Few interventions for countering vaccine hesitancy are supported by evidence.[26] In particular, there is little reason to believe that factual communication, of the sort minimally required in Michigan's mandatory vaccine education, leads to increased vaccination compliance for those subject to educational interventions.[27] With the exception of the 39% subsequent vaccination rate of the alternative schedule group, the results provide further reason for skepticism about such interventions, especially when they are directed at parents who are sufficiently committed to vaccine refusal so as to undertake the burdens of attending an education session at a local health department.

Some have argued that invocations of religion as a refusal reason are often insincere and motivated primarily by secular considerations.[28] This study's results show that children of parents who were members of the religion group had subsequent vaccination behaviors that were significantly different from those of other refusal groups. Vaccine refusers living in states (including Michigan) that offer both religious and personal belief

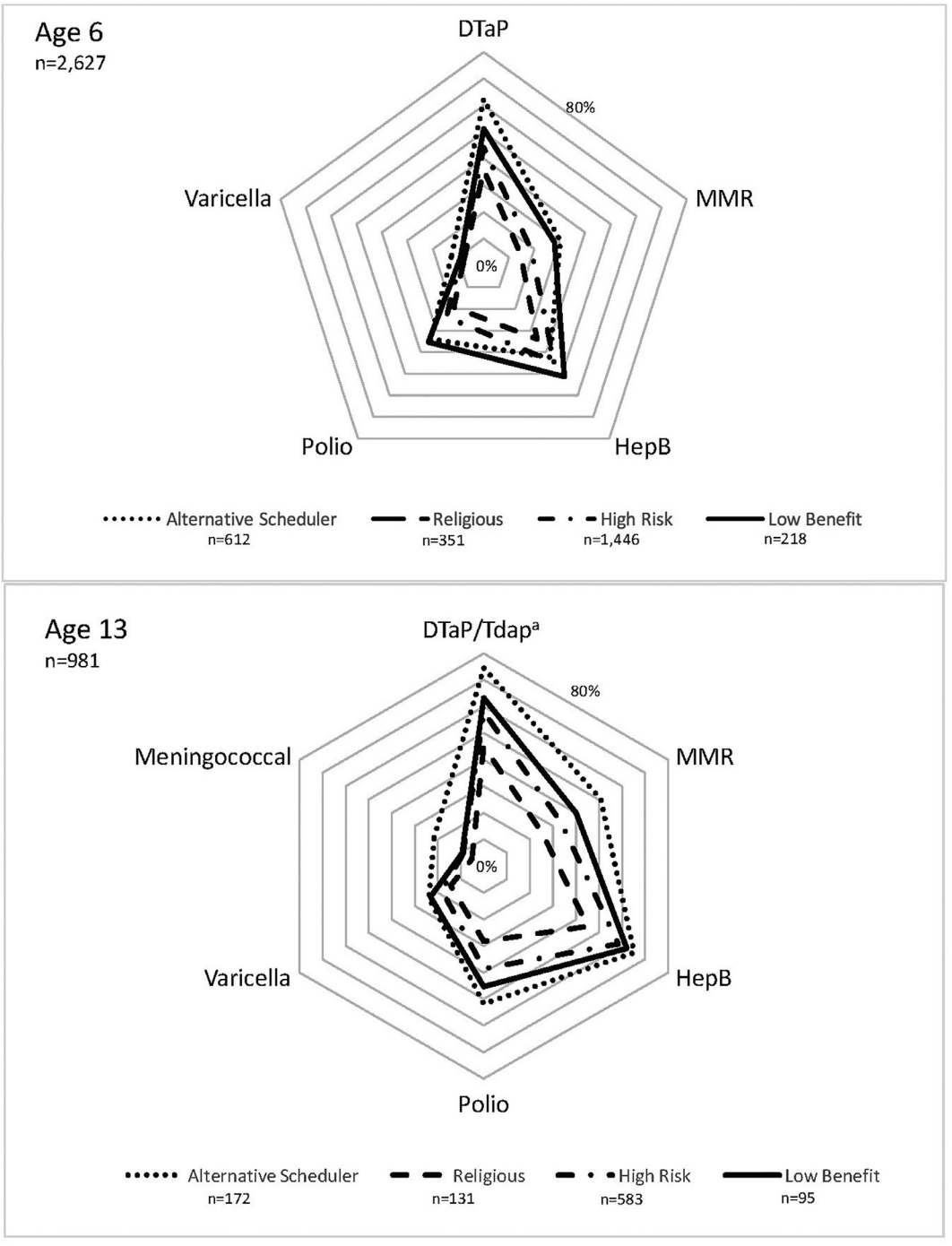

Figure 1. Percentage fully vaccinated by disease and refuser group.
[a]DTaP/Tdap completion rate coded having completed required total immunizations at age 13 from either DTaP series or Tdap booster.
DTaP, diphtheria–tetanus–attenuated pertussis; Tdap, tetanus, diphtheria, acellular pertussis; MMR, measles, mumps, and rubella; HepB, hepatitis B.

exemptions have less reason to offer insincere religious objections than do vaccine refusers living in states that offer only religious exemptions. Even if parents in the religion group had secular motivations, they behaved as one would expect true believers to behave (i.e., they were least likely to change their vaccination beliefs based on factual discussion about vaccines).

Among children in the alternative schedule group, 39.2% received a vaccine their parents had refused in the 7–19 months after education sessions. These parents

Table 1. Group Differences in Vaccine Completion per School-Required Vaccine

	Age 6 years		Age 13 years	
Vaccine	**Sig.**	**Significant pairwise comparisons (*p*-value)[a]**	**Sig.**	**Significant pairwise comparisons (*p*-value)[a]**
DTaP/Tdap	<0.001	a>r (<0.001); a>h (<0.001); a>l (0.003); r<h (0.026); r<l (0.002)	<0.001	a>r (<0.001); a>h (<0.001) r<h (0.046); r<l (0.040)
MMR	<0.001	a>r (<0.001); a>h (<0.001); r<l (0.001); h<l (0.026)	<0.001	a>r (<0.001); a>h (<0.001)
Polio	<0.001	a>r (<0.001); a>h (<0.001); r<l (<0.001); h<l (0.005)	<0.001	a>r (<0.001); a>h (0.015)
Varicella	0.043	—	0.133	—
Hepatitis B	<0.001	r<h (0.001); r<l (<0.001)	0.004	a>r (0.003); r<h (0.038)
Meningococcal	—	—	<0.001	a>r (<0.001); a>h (0.002); a>l (0.036)

Note: ">" denotes completion rate is greater than; "<" denotes completion rate is less than.
[a]All post facto tests performed using Tamhane's T2.
a, alternative schedule; DTaP, diphtheria–tetanus–attenuated pertussis; h, high risk; l, low benefit; MMR, measles, mumps, and rubella; r, religious; Sig., significance; Tdap, tetanus, diphtheria, acellular pertussis.

may have been moved by the educational session or may have reached the point at which they were already planning to receive that particular vaccine. Parents of the other 60.8% of the alternative schedule group may have been following a schedule with fewer doses, or an especially delayed schedule; or these parents may have offered alternative schedule as a refusal reason because they thought doing so would cause less conflict with public health staff. This would be consistent with other findings about parents' strategic invocation of alternative schedule as a means to avoid confrontation.[29]

Important themes arise from analysis of the on-time vaccination rates for children whose parents refused vaccines for different reasons. First, with some exceptions (noted below), children of parents in the alternative schedule group had the highest rates of completion at ages 6 and 13 years, whereas children of parents in the religion group consistently had the lowest rate of completion at both ages. At the same time, the rate of completion for all refuser groups tended to vary similarly for different vaccines. For example, among all refuser groups, the highest rates of completion were for diphtheria–tetanus–attenuated pertussis and hepatitis B; rates tended to be substantially lower for measles, mumps, and rubella; polio; varicella; and meningococcal vaccines. This result, which is consistent with results from the broader Michigan population,[30] suggests that there are disease-specific or vaccine-specific reasons that affect refusal for all refusal groups, not only for those who are in the low-benefit or high-risk groups. This is perhaps most pronounced for varicella, where despite the significance of aggregate between-group differences at age 6 years, no significant pairwise differences manifested, whereas between-group differences were not significant even in the aggregate at age 13 years (though this also may be related to the smaller sample size). A broad perception that varicella is not serious may suppress vaccination rates across all groups, regardless of parents' primary reason for refusal. Contrast this with diphtheria–tetanus–attenuated pertussis and measles, mumps, and rubella, where the rate of vaccination among children whose parents are in the alternative schedule group is nearly twice the rate for those citing religion as the reason for refusal.

Second, for most vaccines, the completion rate at age 6 years for children of parents in the alternative schedule group is higher than for all other refuser groups or is ascending at a rate that suggests it will outstrip rates from other refusal groups. Notably, this is not the case for polio and hepatitis B, where children of parents in the low-benefit group maintain both the highest rate of completion and a trajectory that matches those of children whose parents are in the alternative schedule group. This may indicate that parents in the low-benefit group believe polio and hepatitis B to be especially dangerous relative to other diseases. Perhaps most interestingly, although children whose parents are in the high-risk group have slightly higher compliance rates than children whose parents are in the religion group, both groups tended to have the lowest vaccination rates and their patterns of completion across time consistently mirror each other, even as the patterns for the other two groups diverge. This may suggest that the high-risk and religion groups share an underlying orientation toward decision making about vaccination that is either skeptical of science or that grants significant weight to values that are resistant to scientific evidence (e.g., purity); furthermore, some parents may have invoked religion rather than high risk to avoid confrontation about their beliefs (as may have been the case for some in the alternative schedule group).[18]

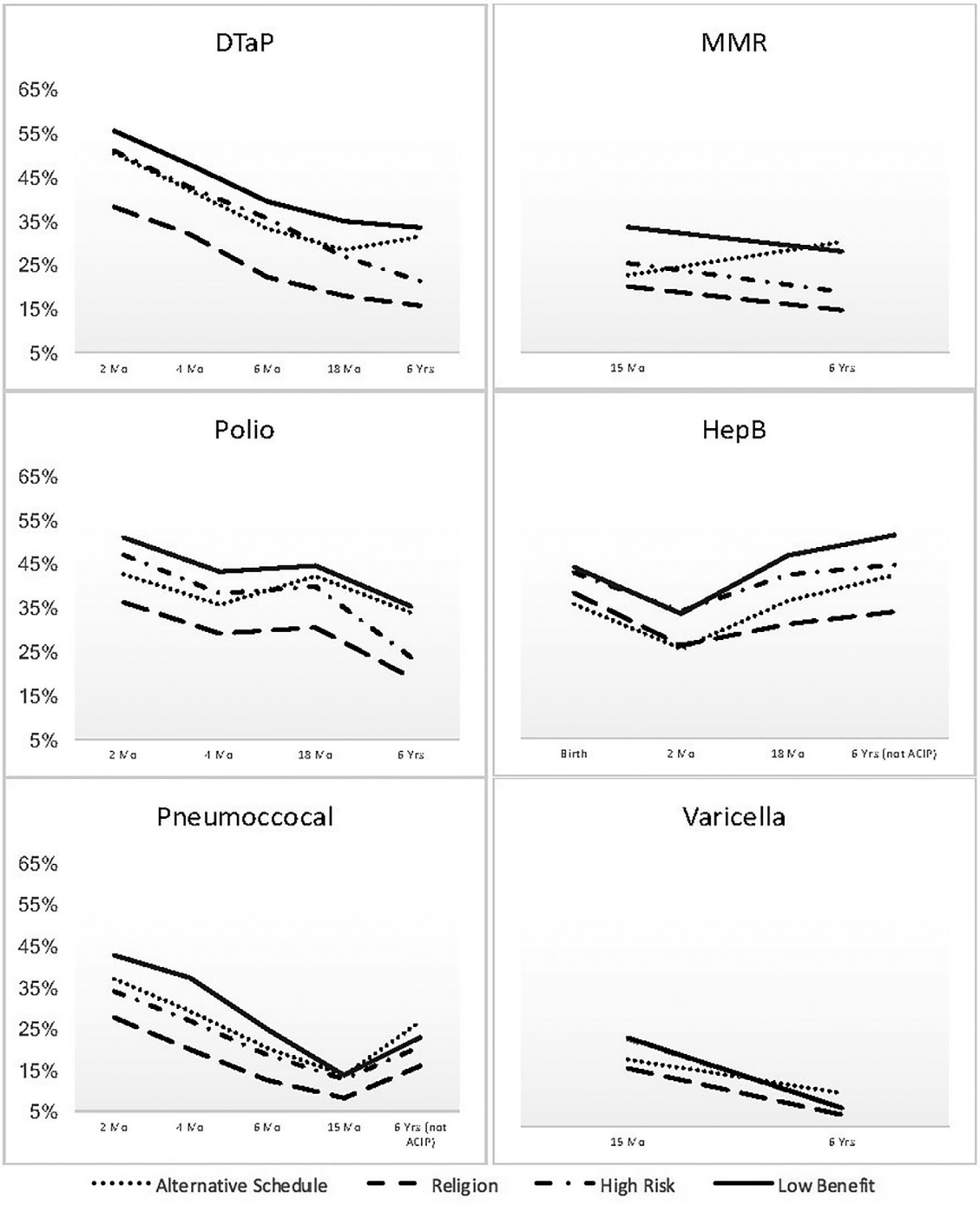

Figure 2. Vaccine completion rate at each ACIP time point by refusal group (n=2,627).
ACIP, Advisory Committee on Immunization Practices; DTaP, diphtheria–tetanus–attenuated pertussis; MMR, measles, mumps, and rubella; HepB, hepatitis B.

Limitations

Each parent's refusal was assessed once, which prevents determining, among the parents for whom no refusal reasons are recorded, which of them changed their minds during the session. Also, waiver educators may not have always made separate inquiries about refusal reasons for each vaccine, so the fact that almost all (97.2%) parents have the same refusal reason may overstate their unanimity. That only one refusal reason was recorded for each vaccine is a further limitation. Additionally, the religion code is unable to distinguish between those whose religion prohibits vaccines and

Table 2. Differences in Vaccine Completion Among Refuser Groups by Vaccine for Children Aged ≥6 Years (*n*=2,627)

Vaccine	Birth sig.	Pairwise (*p*-value)[a]	2-mo sig.	Pairwise (*p*-value)[a]	4-mo sig.	Pairwise (*p*-value)[a]	6-mo sig.	Pairwise (*p*-value)[a]	15-mo sig.	Pairwise (*p*-value)[a]	18-mo sig.	Pairwise (*p*-value)[a]	6-years sig.	Pairwise (*p*-value)[a]
DTaP	—	—	<0.001	a>r (0.001) r<h (<0.001) r<l (<0.001)	0.001	a>r (0.012) r<h (0.001) r<l (0.001)	<0.001	a>r (0.001) r<h (<0.001) r<l (<0.001)	<0.001	a>r (<0.001) a>h (0.032) r<h (0.001) r<l (<0.001)	<0.001	a>r (0.001) r<h (0.001) r<l (<0.001)	<0.001	a>r (<0.001) a>h (<0.001) r<l (<0.001) h<l (0.002)
MMR	—	—	—	—	—	—	—	—	0.002	a<l (0.016) r<l (0.003)	—	—	<0.001	a>r (<0.001) a>h (<0.001) r<l (0.001) l>h (0.026)
Polio	—	—	<0.001	r<h (0.001) r<l (0.004)	0.002	r<h (0.005) r<l (0.005)	—	—	—	—	0.001	a>r (0.001) r<h (0.005) r<l (0.005)	<0.001	a>r (<0.001) a>h (<0.001) r<l (<0.001) h<l (0.005)
HepB	0.010	a<h (0.011)	<0.001	a>h (<0.001) r<h (0.021)	—	—	—	—	—	—	<0.001	a<l (0.049) r<h (<0.001) r<l (0.001)	<0.001[b]	r<h (0.001) r<l (<0.001)
Varicella	—	—	—	—	—	—	—	—	0.015	r<h (0.031)	—	—	0.043	None
Pneumo.	—	—	<0.001	a>r (0.016) r<l (0.002)	<0.001	a>r (0.007) r<h (0.028) r<l (<0.001) h<l (0.020)	0.002	a>r (0.008) r<h (0.019) r<l (0.002)	0.071	a>r (0.042) r<h (0.049)	—	—	0.001[b]	a>r (<0.001) a>h (0.023)

Note: ">" denotes completion rate is greater than; "<" denotes completion rate is less than.
[a]All post facto tests performed using Tamhane's T2.
[b]Denotes a time point that is not part of the ACIP recommendation.
a, alternative schedule; DTaP, diphtheria–tetanus–attenuated pertussis; h, high risk; HepB, hepatitis B; l, low benefit; MMR, measles, mumps, and rubella; mo, month; Pneumo., pneumococcal; r, religious; sig., significance.

those who interpret their religion's dogma as prohibitive. The alternative schedule code is unable to distinguish between parents who schedule fewer doses and parents who slow the standard dose delivery. Finally, the methodology for generation of ORs and referents cannot discern latent structural differences in the distributions of subgroups on key factors, given the population sizes involved in this study.

CONCLUSIONS

This study's finding of relatively low rates of subsequent vaccination for people who refuse vaccines for reasons other than a commitment to an alternative schedule should inform discussions about the efficacy of factual communication for countering vaccine hesitancy. Although 16.4% (657/3,999) of children subsequently received a vaccine their parents refused, 70.5% (463/657) of the children who subsequently received a refused vaccine had parents in the alternative schedule group. Many of these parents may have vaccinated their children later even in the absence of the education session. This result is relevant for communities that require or are considering requiring education sessions as part of their processes for granting NMEs. Although this paper's results do not offer decisive guidance regarding the adoption of education requirements, such policies can be effective at reducing NME rates, as Michigan's experience illustrates.

The existence of robust differences in vaccination behaviors of parents who refuse vaccines for different reasons suggests that different refusal reasons correspond to different parental motivations. Thus, different interventions may be effective for different refusal groups. For example, some religiously motivated vaccine refusals may be countered if religious leaders communicated with their congregations about the moral imperative of vaccination, or if vaccine manufactures eliminated ingredients from vaccines derived from aborted fetal tissues. Parents who refuse vaccines because they are unconcerned about vaccine-preventable diseases may become more likely to vaccinate if they realized vaccine-preventable diseases are serious, herd immunity is fragile, and international travel makes everyone vulnerable. It may be more difficult to reach parents who refuse vaccines because of concerns about vaccine safety, especially if their worries are not responsive to evidence about the low risk of vaccine complications, but are instead motivated by concerns about unnatural ingredients.[18,31]

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SUPPLEMENTAL MATERIAL

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